General Magnetic Sciences, Inc. Technology Overview

General Magnetic Sciences, Inc. is a technology development company incorporated in Delaware and operating in Virginia. GMS has developed unique, patented and proprietary technologies that exploit the magnetic portion of the electromagnetic wave to make possible a wide variety of applications for the energy markets. These two key technologies, briefly, are:

- Magnetic Transparencies – the ability to pass magnetic waves through barrier materials, including carbon steel, once thought impossible, and to sense and analyze spectrographically the materials on the other side of the barrier.

- Wavelength Compression Antennas – the capability to transmit very long wavelength (low frequency) signals from antennas physically much smaller than the wavelength of that signal in air but still "electromagnetically large" to achieve high transmission power and efficiency.

These two core technologies, alone and in combination, offer the possibility of innovative solutions to challenges in every aspect of the energy cycle from exploration to production and monitoring to faster, more efficient ways to conduct non-destructive inspection of pipelines and storage facilities.

Through the Casing Monitoring and Measurement – Current systems for monitoring conditions outside of a cased well rely on resistivity measurements and are effective only within a couple of meters of the casing, under most conditions. By creating a "magnetic transparency" at the desired location on the well casing and then using GMS's highly efficient "compressed wavelength antennas" to send a signal through that transparency, tremendous advances in capability are possible –

- Orders of Magnitude Increases in Range – The effective range of this sensor system could be from tens of meters to many kilometers,
- Unprecedented Situational Awareness – GMS has shown that these signals can be used to "spectrographically" analyze the materials they encounter, users would now be able to detect everything from an encroaching water front to other deposits that had been missed, and
- Mapping the Surrounding Strata – Because these signals would be highly directional, it would be possible to fix the location of these deposits and other elements of interest in the strata.
- Adaptable – These systems are rugged and can be adapted for use in the drill-string applications; for monitoring of cement integrity; and for detection of cracks, corrosion, and other defects in pipelines without the need to remove coverings or use of ionizing radiation, among many other applications.

Potential Applications –

- **Through-Casing Monitoring and Measurement** – Measure, map, and monitor conditions and strata surrounding cased wells out to many meters.
- **Measurement While Drilling** – Extend sensor ranges significantly.
- **Pipeline Inspection** – Detection of cracks, corrosion, pitting, etc. without need for removing insulation or protective coatings. Portable and requiring no ionizing radiation.
- **Routine non-destructive inspection** of pipelines, storage tanks, and pressure vessels without the need to evacuate object to be inspected – saving vast amounts of service time lost to preparation, cleaning, etc.
- **Monitoring of cement integrity** in producing or closed wells
- Monitoring for cracks or defects in turbine blades while in operation.
- Detection of cracks in railroad tracks while at full operating speed.

Producing from New, Non-Traditional Sources – The viability of exploiting hydrocarbon deposits ranging from newly discovered natural gas fields, to heavy oil, oil sands and shale, and other similar sources can depend on a number of factors. While the cost to recover the product compared to its price on the open market may be the key determinant, increasingly the ecological effects of some methods of recovery have resulted in increased resistance to their use in many situations.

GMS modeling indicates the possibility of using a powerful wavelength compression antenna to provide the heating that would free the hydrocarbons. Further, the advantages of this method would include, among others –

- In-Situ Heating – Proprietary methods could eliminate use of much, if not all, water currently required while requiring no additional holes/wells to be drilled
- More efficient – No need to heat water to produce steam to be injected into the site.
- Reduced ecological impact – No need to pump large amounts of water, especially in areas where water is scarce; and greatly reduced – and depending on conditions, zero – requirement for other "critical fluids" to be added

GMS is currently operating compressed wavelength antennas at low frequencies for communications applications. As an example, in these tests, GMS is generating a 100 Hz signal (λ = 3000 km in air) from an antenna only 12" square – and transmitting with the effectiveness of an antenna equal in size to a full wavelength – a compression ratio greater than 10^7:1. During the development of these antennas, GMS has gained significant experience and insight into the challenges of applying high power to relatively compact antennas. Additionally, GMS has developed a unique finite element analysis modeling program that has added insight into the range of possible applications and capabilities achievable with these technologies.

In addition to the patents for the two core technologies noted above, John Menner, founder and Chief Technology Officer of GMS has 18 other patents that relate to many of

the related technologies needed to implement the many applications that flow from these core technologies, some of which would include –

- **Exploration** – The ability to transmit low frequency waves from platforms small enough to be mobile combined with the ability to recognize and locate features of interest in the strata below will make possible new ways to quickly survey large areas. These systems will be small enough and could be autonomous enough to allow surveying to be conducted using unmanned aerial vehicles (UAVs) over land and unmanned undersea vehicles (UUVs) to survey deep sea areas.
- **Detection** – Because this technology is scalable in frequency, it can be useful for a wide range of other detection applications ranging from the critical to the mundane, e.g. –
    - Detection of Improvised Explosive Devices (IEDs) at stand-off ranges sufficient to provide troops protection from the single most lethal threat they face
    - Man portable systems capable of locating and sizing pipelines and other infrastructure buried many meters in depth
- **Communications** – Because the signals produced by compressed wavelength antennas are strongly biased to the magnetic component of the electromagnetic wave (up to millions of times stronger), these signals are much more effective at penetrating materials that would block "normal" signals. Given the relatively small size of a compressed wavelength antenna and its scalability across the frequency spectrum, these antennas provide significant advantage in a number of difficult communications scenarios –
    - Wireless communication to and from miners – in routine and emergency situations – without reliance on fixed infrastructure or wiring
    - Reliable, portable communications for first responders operating in tall building and subway tunnels
    - Communications for troops in the field in complex urban terrain, heavily vegetated jungles, or in caves and mountainous
    - Improved cell-phone communications from inside buildings
- **Screening** – With the ability to "see" through carbon steel and analyze materials on the other side and because GMS technology does not rely on ionizing radiation, solutions for safely and quickly screening everything from cargo to airline passengers are possible. The magnetic field generated by GMS systems is never more that a tiny fraction of that of a Magnetic Resonance Imaging (MRI) system (and there is no "lethal dose" of MRI). Some potential applications would include –
    - Shipping Cargo Screening – Using this technology, it would be possible to screen every container going onto and coming off of every ship. Cargo could be screened and the analysis compared to the manifest and containers set aside for additional inspection only where a discrepancy is noted. Current systems screen only a small percentage of containers and none is capable of doing that screening during the normal loading/un-loading process.

- Air Cargo Screening – Similarly, all packages being shipped as air cargo could be passed through a security portal.
- Passenger Screening – By focusing on detection of the signatures of explosives, or their component parts, this technology could be used to complement other systems to screen passengers quickly and without resort to the "hands-on" treatment that has gained so much notoriety, of late.